Pressure Safety Orientation

FN 000000271/CR

Objectives

- Make user familiar with terms and definitions
- Be aware of hazards associated with pressurized gas sources
- Identify components of pressurized gas systems

What This Course Will Not Do

- Qualify you to design, fabricate, or test pressure vessels
- Authorize you to use oxy-acetylene equipment

Additional training and experience is required. Contact your supervisor for requirements.

Pressure Safety References

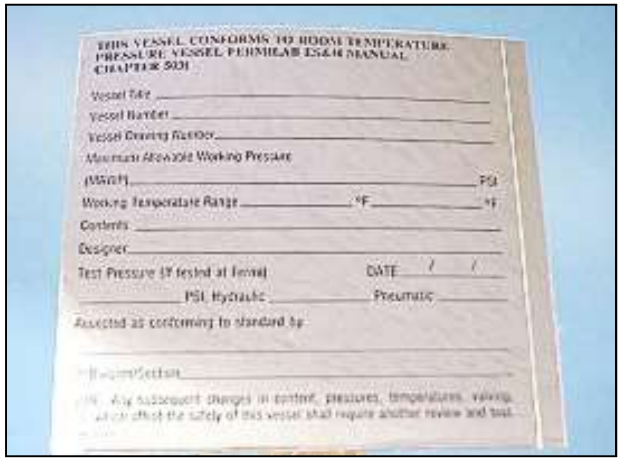
- Fermilab ES&H Manual (FESHM)
  - FESHM 5031 is Fermilab's Pressure Safety Reference. It contains:
    - Responsibilities of Division/Section Heads, Mechanical Safety Subcommittee, and employees
    - Process for design, fabrication, testing, and using pressure vessels
    - Requirements for Engineering Notes for all new and existing pressure vessels

Pressure Safety References

- FESHM 5031 also addresses design and documentation
  - Pressure vessels and systems shall be designed and documented in accordance with FESHM 5031 and its appendices
  - An Engineering Note is a written analysis demonstrating that a given vessel satisfies the requirements of this chapter

Pressure Safety References

- FESHM 5031 (Cont'd)
  - Vessels that operate above 15 psi and have a minimum dimension larger than 6 inches requires formal engineering review
  - Metallic silver sticker is attached when review is complete



Pressure Safety References

- FESHM 5034 (Pressure Vessel Testing)
  - Requires all pressure vessels to be tested to assure they can be operated safely
  - Pressure tests performed & documented by outside manufacturer need no be repeated
  - Requires testing permit to assure testing will be conducted safely

Pressure Safety References

- FESHM 5031.1 (Pressure Piping)
  - Outlines procedures for designing, fabricating and testing pressure piping systems

Pressure Safety References

- Engineering Notes for Pressure Vessels
  - FESHM 5031 Technical Appendix
- Contact List 
  - When you need further help and information contact your Division Safety Officer (DSO)
- Compressed Gas Cylinder training
  - Available on the TRAIN database

Definitions

- Qualified Person
  - A person who has successfully completed this course (Pressure Safety Orientation) and the Compressed Gas Cylinder Training

Definitions

- M.A.W.P.
  - Maximum Allowable Working Pressure
  - MAWP has a temperature for which it is valid
    - Temperature should be noted on silver sticker or the vessel nameplate

Definitions

- M.O.P.
  - Maximum Operating Pressure
  - Set 10%-20% below M.A.W.P.
  - QUESTION #1: Can you safely operate at 150 % M.A.W.P.?
    - answer

Definitions

- Burst Pressure
  - Pressure at which the vessel catastrophically fails, releasing its contents
  - Question #2: Which is greater, the burst pressure of a vessel or the MAWP?
    - answer

Definitions

- Relief Pressures
  - The set pressure at which the relief valve cracks open is set equal to or lower than the M.A.W.P
  - The pressure at which the relief valve will be fully open is typically 10% greater than the set pressure, but significantly below the burst pressure

Pressure Safety Program

- Concept
  - All pressure systems must be designed, tested, inspected, and used in accordance with sound engineering principles by qualified and trained personnel in accordance with FESHM 5031, 5031.1, 5031.2, 5031.3, 5031.4, 5031.5, and 5034.

Pressure Safety Program

- FESHM 5031 – outlines policies, procedures, and requirements
- Mechanical Safety Subcommittee - responsible for recommending guidelines for the fabrication, testing, installation, and use of mechanical systems for experimental and laboratory applications.
- Division Safety Officers – provide daily guidance in program implementation
- Qualified Person – **YOU**

Pressure Safety – the Basics

Pressure Relief Devices

- Pressure relief devices are the most important component for the safety of pressurized systems
  - These devices prevent the pressure equipment from reaching the burst pressure, where the explosion could cause injury or death to personnel
- If you are working on or near pressure relief devices, then hearing and eye protection should be worn if the system is operational. Depending on the conditions, a relief event can be quite loud.
  - Note that in most cases, a LOTO procedure will be required prior to working on a pressure relief device
- Note that the sudden opening of a pressure relief device is a potential startling hazard. Always scan the area for nearby pressure relief devices before starting your work.

Pressure Relief Devices

- Never touch a pressure relief device unless you have been given a specific procedure and/or training
- Qualified personnel at Fermilab regularly inspect and test relief devices to verify functionality per FESHM 5031.4. Only the personnel trained for these tasks should touch pressure relief devices
- If you suspect a problem with a pressure relief device, then contact a system expert or leader of the group responsible for that system. The DSO is available to help locate this system expert
- Fermilab employees should not touch the relief valves on pressure vessels, dewars, and other equipment that is not owned by Fermilab. The vendor responsible for the equipment should contacted for inspection, maintenance, and repair

Operating Tips

- With high pressure regulator always use gauge
- Low pressure (psig) X high surface area (square inches) creates a lot of stored energy & force
- Use good design and compatible materials
  - PVC is fine for low pressure water, but not for compressed gases
- Know how to have a safe assembly
  - Working pressure gauge scale should be at least 120% of MAWP

Operating Tips

- **DO NOT** mix oxygen and oil
- **DO NOT** misuse equipment
- Follow procedures
- Follow established procedures &/or Hazard Analysis
  - See your supervisor if you have any questions

Operating Tips

- Always tie down hoses
  - QUESTION #3: What is the weakest part of the hose?
    - answer
  - QUESTION #4: What can happen if a hose breaks?
    - answer
- Get rid of dirty or damaged regulators
  - Dirt in regulator can cause it to fail
- Lock and tag equipment - verify there is no pressure

Operating Tips

- Get rid of dirty or damaged regulators
  - Dirt in regulator can cause it to fail
- Lock and tag equipment any pressurized gas before working on system
  - Verify there is no pressure
  - Pressurized gasses are stored energy
  - See FESHM 2100 for information

NOTE: LOTO training is required before performing LOTO

AIR COMPRESSORS

Air Compressors

- Most common pressure vessels on site are air receivers
  - Purchased with attached air compressor
- Make sure there is an ASME stamp
  - Guarantees vessel was built in compliance with pressure vessel code
- Vessels fabricated at Fermilab need:
  - Engineering Note
  - Pressure testing

Air Compressors

- Relief valve must be installed so that vessel cannot exceed its design pressure
  - Valve is also ASME stamped
  - Valve must be inspected every 3 years, tested or replaced every 6 years
  - Valve must be able to relieve as much gas as the compressor can supply
  - Question #5: What happens if relief valve opens at 100 psi, but cannot pass as much gas as compressor is delivering
    - answer

Air Compressors

- Portable Compressor with Hot Dog Style Tank
  - Operate at 125 psi
  - Since vessel diameter is less than 6 inches, no formal review is required
  - Does not require silver sticker

Air Compressors

- Portable Air Receiver
  - Vessel purchased without an attached compressor
  - Pressurized with in-house compressor
  - Vessel diameter is greater than 6 inches, and operated at 100 psi, so it requires a formal review

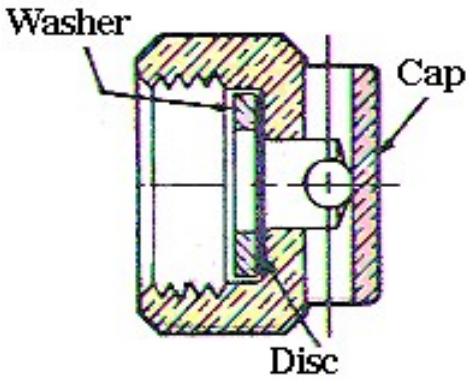
CYLINDERS

Cylinder Design

- Design and use is per Department of Transportation (DOT) specifications
  - Ex. DOT 3AA
- Standard 2000 psig cylinder has 1.5 cubic feet of water volume (~200 standard cubic feet of gas)
- Standard cylinder is 9” outside diameter and 50” high
- Cylinders are NOT intended to be used or stored in areas > 125 degrees F
- Cylinders need to have regulator attached before use

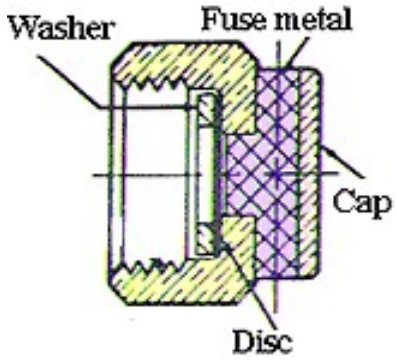
Cylinder Relief Devices

- Relief Device must be compatible and never modified!!!



Frangible Disc

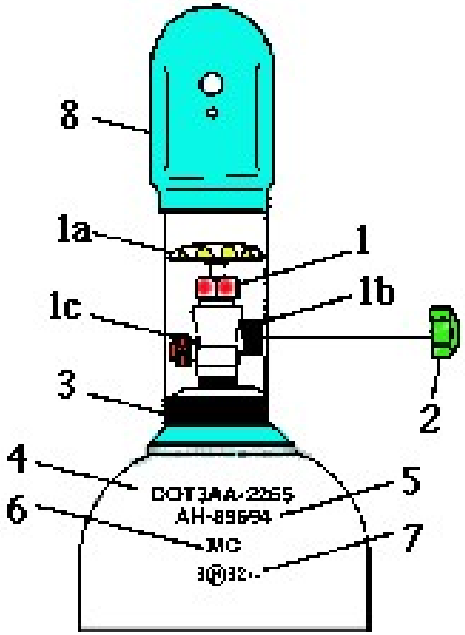
- **Used with CO2, N2, O2, Ar, He**
- **Does NOT reseal when pressure goes down**



Frangible Disc Backed by Fusible Material

- **Used with Hydrogen, CH4**

Common Gas Cylinder Features



1. **Valve: (a) hand wheel, (b) CGA outlet connection, (c) pressure relief device**
2. **Valve outlet cap**
3. **Cylinder collar**
4. **DOT specification (3AA is the size) and service pressure (2,265 psig)**
5. **Serial Number**
6. **Manufacturer's symbol (MC)**
7. **Test Date – for Vendor only – includes original tester's symbol**
8. **Cylinder cap**

Cylinder Identification

- DOT Shoulder Labels is the only method to identify what's in cylinder
- Tags are not always reliable
- Beware of mislabeled equipment
- **DO NOT Depend on Color Codes**
  - There is no standardization

Shoulder Labels

- Shoulder label is required for documentation, accountability, and tracking
- Label contains information on:
  - Chemical content
  - Health hazards
  - Reactivity

Status Tags

- Status tags identify whether cylinder is full, in service, or has residual pressure

Proper Handlings and Transporting

- ALWAYS move or transport cylinder with regulator off and protective cap installed
  - Especially in pickup trucks!
- ALWAYS use hand truck, forklift truck, cylinder pallet system and procedures established by your division/section
- Use cylinder carts – **NOT YOUR BACK**
- When lifting with crane - use lifting fixture
  - Do not sling individual cylinders

Cylinder Caps

- Protect valve with cylinder cap
- Caps come off easily ---**DO NOT** lift by the cap
- QUESTION #6: If cap is stuck, can you loosen with penetrating oil?
  - answer

Proper Use of Cylinders

- ALWAYS secure cylinder
  - Except when moving it
- Use chains or straps (2/3 of the way up)
- Use storage racks
- Back out adjusting handle on a regulator before opening the cylinder valve to reduce pressure

Proper Use of Cylinders

- Leave some residual gas in cylinder
  - Typically ~20 psi
- ONLY vendors can refill vendor-owned cylinders
- If cylinders are corroded or appear damaged, send back to vendor

Cylinder Storage

- Separate full from empty cylinders
- Separate oxidizers from flammables by AT LEAST 20 feet or a ½ hour fire wall
- Store cylinders upright
- Keep out of direct sunlight

Cylinder Storage

- Chain/strap cylinders
- Don’t put cylinders in walkways
- Provide clear warning signs for toxics and corrosives
- Notify SSO for storage requirements for toxics
- QUESTION #7: When can you store cylinders side by side?
  - answer

Propane Cylinders

- Cylinders come in 3 sizes
  1. On torches (14 – 16 oz.)
     - When empty, dispose of cylinder
  2. Grill & Campers (20#)
     - Can refill cylinder, but only with propane
     - Cylinders are refilled by vendor
  3. Fork Trucks (~65#)
     - Available in stockroom
     - Refilled by vendor

Cylinder Valves

- **Do not attempt to fix valve**
- **Never remove cylinder valve!**
- Cylinder valve is installed by vendor
- Cylinder valve is matched to gas contained inside

Lecture Bottles and Sample Cylinders

- Typically 15” long x 2” diameter, 500 cc
- Used for samples or specialty gases
- DOT Spec.3E
- Non-returnable—hence no retest required
- User is responsible to properly identify and dispose of the contents

Empty Cylinders

- ALWAYS leave some positive pressure to keep cylinder clean
- Leave about 25 psi and not less than 20 psi
  - Except acetylene cylinders which are only pressurized to 15 psi to begin with
  - Use acetylene cylinders until empty
- More information is found in CGA Handbook and Compressed Gas Cylinder Safety training

Cylinder Corrosion

- The bottom of the cylinder get the most corrosion
  - If cylinder appears corroded, send back to vendor

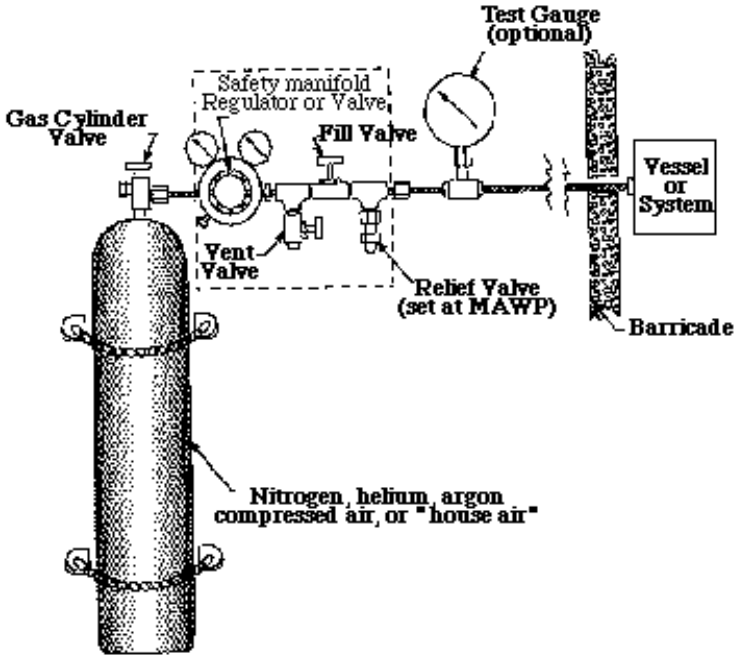
PRESSURE PIPING SYSTEMS

Pressure Piping Systems

- Piping systems contain very large volumes resulting in much stored energy
- Piping systems need to be fitted with relief valves to prevent pressure exceeding the MAWP
- Consult your supervisor or DSO for Lockout/Tagout procedures before working on any piping system

REGULATORS & MANIFOLDS

Manifolds



Manifolds are the bridge between source gas and end use

Functions of Regulators

- Regulate delivery pressure
- Protect from overpressure
- Indicate value of pressure - gauge
- Vent unused excess gas
- Throttle (meter) gas into its end use

Lessons Learned

- In 2015, an incident occurred during a high pressure test of a pressure relief valve (PRV).
  - The PRV contacted the employee in the back of the head after ricocheting off of the ceiling resulting in a laceration.
  - The injury could have been much more severe.
  - The PRV was not threaded properly and when brought up to pressure the valve exited the test apparatus.

Lesson Learned

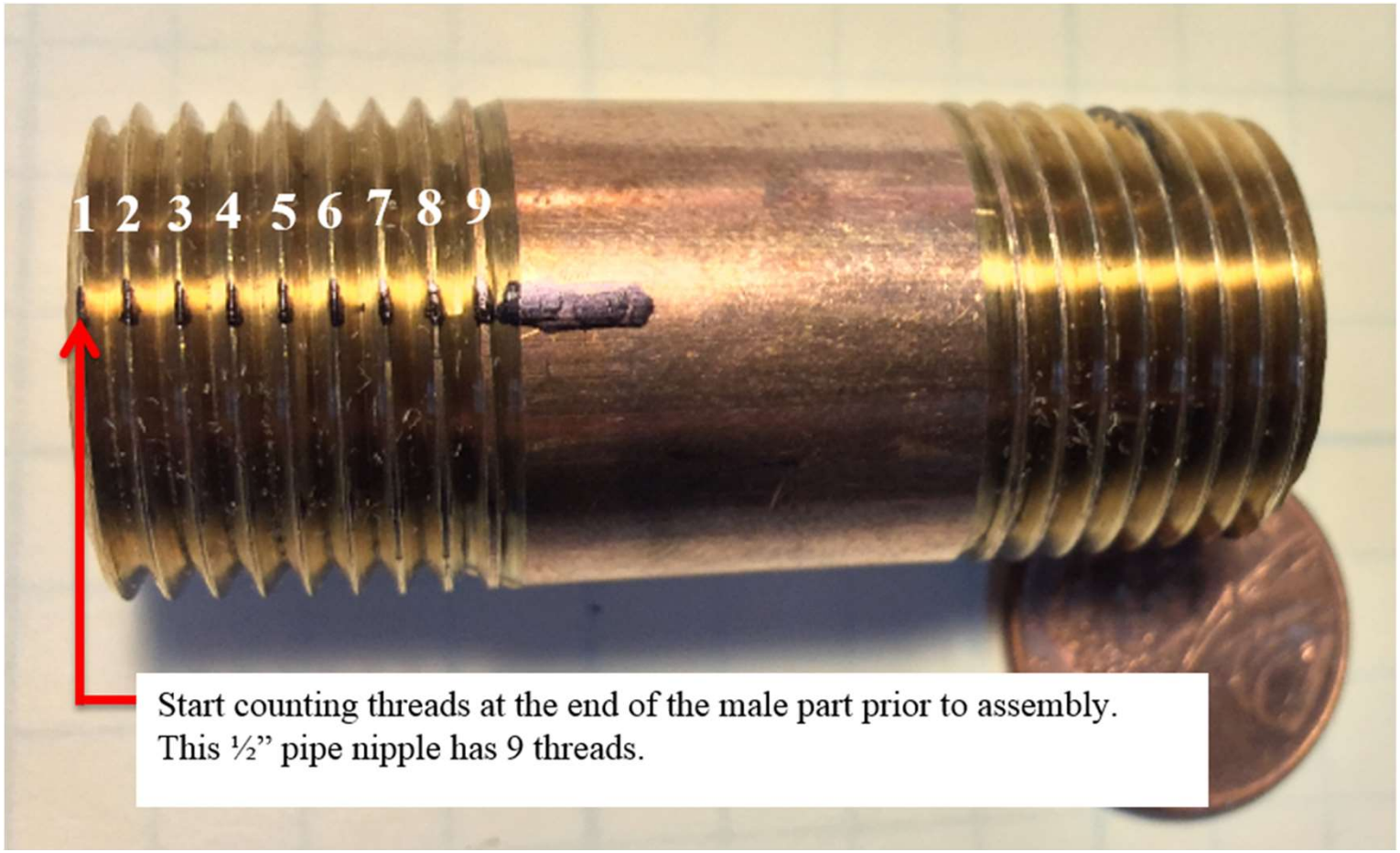
- Causal factors of the PRV incident
  - Employee used stainless steel bushings to get the correct sizing, stainless steel on stainless steel can lead to galling and lack of thread engagement (occurred in this incident).
  - Use carbon steel or other appropriate material to reduce potential for galling, count threads to ensure proper engagement. Low pressure leak check to check for proper sealing.
  - When using two fittings of the same material galling is more likely, so inspection of the threads is even more important.
  - Using dissimilar materials is ideal to reduce potential galling.

Lesson Learned

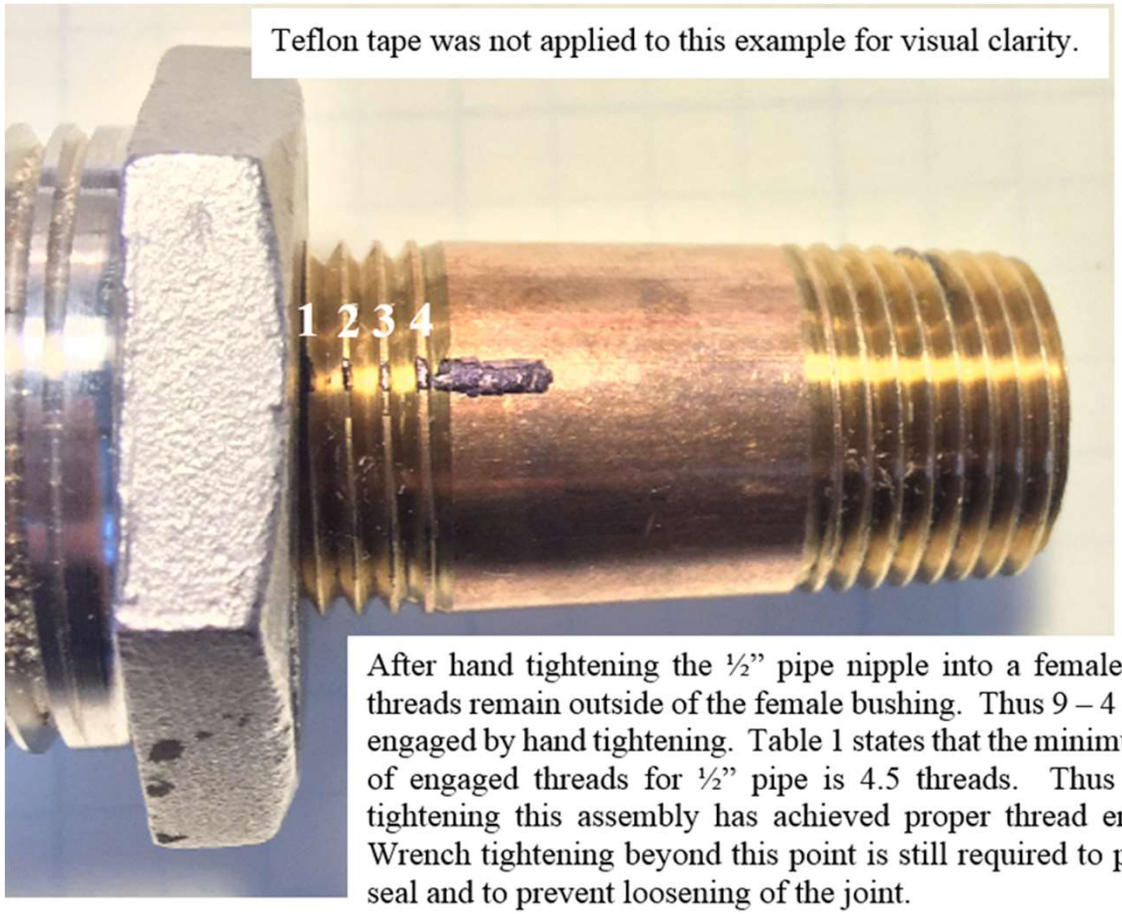
- Causal factors of the PRV incident
  - Employee utilized the blow down pipe of the PRV to tighten the equipment.
  - Use proper tools to tighten each bushing (one at a time).

Lesson Learned

- Thread Engagement



Lesson Learned



After hand tightening the ½" pipe nipple into a female bushing 4 threads remain outside of the female bushing. Thus 9 – 4 = 5 threads engaged by hand tightening. Table 1 states that the minimum number of engaged threads for ½" pipe is 4.5 threads. Thus after hand tightening this assembly has achieved proper thread engagement. Wrench tightening beyond this point is still required to produce the seal and to prevent loosening of the joint.

Note that counting turns is NOT compatible with the numbers listed in Table 1 and this method should not be used.

Lessons Learned

Table 1 – (from previous slide) Excerpt from ASME B1.20.1-2013 highlighting the minimum and maximum number of engaged threads for common pipe sizes.

Nominal Pipe Size Inches	Minimum Engagement Length Inches	Minimum Number of Engaged Threads*	Maximum Number of Engaged Threads**
1/16	0.16	4.3	7.3
1/8	0.16	4.4	7.4
1/4	0.23	4.1	7.1
3/8	0.24	4.3	7.3
1/2	0.32	4.5	7.5
3/4	0.34	4.8	7.8
1	0.40	4.6	7.6
1-1/4	0.42	4.8	7.8
1-1/2	0.42	4.8	7.8
2	0.44	5.0	8.0
2-1/2	0.68	5.5	7.5
3	0.77	6.1	8.1
3-1/2	0.82	6.6	8.6
4	0.84	6.8	8.8
5	0.94	7.5	9.5
6	0.96	7.7	9.7
8	1.06	8.5	10.5
10	1.21	9.7	11.7
12	1.36	10.9	12.9

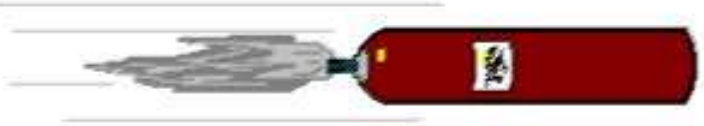
*The pipe thread fitting must be tightened ***beyond*** the minimum number of engaged threads

**If the pipe thread fitting is tightened beyond the maximum number of engaged threads it may be worn and must be discarded.

Lesson Learned

- Ensure proper ratings of fittings, check manufacturer specifications
  - Some typically found brass fittings are only rated for 125psi

The One That Got Away



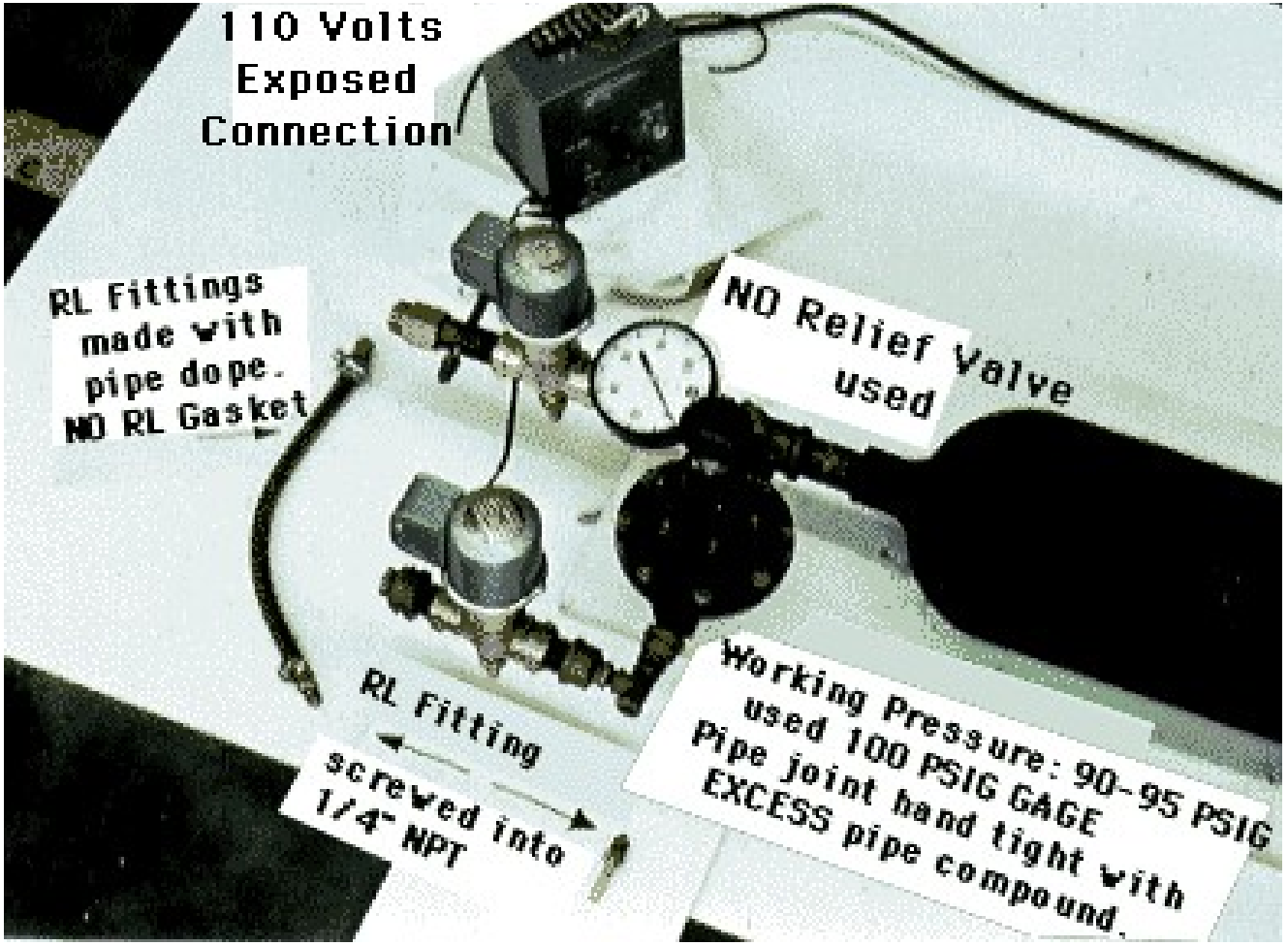
Six 220-cubic foot cylinders, part of a fire extinguishment system, had been moved away from their wall supports to allow painters to complete the painting of the area. While moving them back into position, it was noticed that one cylinder was leaking. The painter had the cylinder leaning against his shoulder, and was attempting to scoot it across the floor. At this time, the valve separated from the cylinder and was projected backward hitting the side of a stainless steel cabinet.

The man suddenly found himself with a jet-propelled 215 pound piece of steel. He wrestled it to the floor, but was unable to hold it. The cylinder scooted across the floor hitting another cylinder, knocking it over and bending its valve. The cylinder then turned 90 degrees to the right and traveled 20 feet where it struck a painters scaffold causing a painter to fall 7 feet to the floor. After spinning around several times, it traveled back to its approximate starting point, where it struck a wall.

At this point, the cylinder turned 90 degrees to the left and took off lengthwise of the room chasing an electrician in front of it. It crashed into the end wall 40 feet away breaking four concrete blocks. It turned again 90 degrees to the right, scooted through a door opening, still chasing the electrician. The electrician ducked into the next door opening, but the cylinder continued its travel in a straight line for another 60 feet, where it fell into a truck well striking the truck well door. The balance of the cylinder pressure was released as the cylinder spun harmlessly around in the truck well area.

The painter who fell from the scaffold received multiple fractures of his leg

Summary



What's Wrong With This Picture?

Summary

- There is a large amount of stored energy within pressure vessels, cylinders, and piping systems
  - Sudden release of this energy can cause serious injury or a fatality
- Compliance with pressure safety rules is the responsibility of everyone who uses pressurized equipment

Test Instructions

- Click below to take the test and get credit for the class

- Take the test